

AIR QUALITY ASSESSMENT STUDIES IN THE TIMMINS AREA

(1975)

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Ministry
of the
Environment

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Air Quality Assessment Studies in the Timmins Area
(1975)

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ONTARIO MINISTRY OF THE ENVIRONMENT
NORTHEAST REGION

February, 1976

7775

Table of Contents

	<u>Page</u>
I INTRODUCTION.....	1
II VEGETATION AND SOIL MONITORING.....	2
A. Plot Establishment	
B. Vegetation Sampling	
C. Soil Sampling	
D. Tree Conditions and Growth Studies	
E. Snow Sampling	
F. Chemical Analysis Results for Vegetation	
G. Chemical Analysis Results for Soil	
H. Results of Tree Condition and Growth Studies	
I. Results of Snow Sampling	
J. Conclusions	
III AIR QUALITY MONITORING.....	6
A. Introduction	
B. Dustfall Analysis	
C. Hi-Volume Sampling	
D. Sulphation Rates	
E. Conclusions	
IV RAILROAD STUDIES.....	10
A. Methods	
B. Results and Observations	
C. Conclusions	
V SPECIAL SURVEILLANCE.....	13
A. Methods	
B. Results and Observations	
C. Conclusions	
VI SUMMARY AND CONCLUSIONS.....	15
VII ACKNOWLEDGEMENTS.....	16
VIII BIBLIOGRAPHY.....	17
APPENDIX	

I. INTRODUCTION:

In November, 1966, the Ecstall Mining Company, a wholly-owned subsidiary of Texasgulf Incorporated began operation of an ore concentrator in Hoyle Township, about 20 kilometres northeast of Timmins, Ontario. This concentrator has been producing zinc, copper, and lead concentrates with cadmium and silver as secondary constituents since that date. In April, 1972, the Company began operation of an electrolytic zinc plant (smelter and refinery) adjacent to the ore concentrator. Zinc and cadmium are produced in the refinery and sulphuric acid is recovered as a by-product of the roasting process. The construction of this complex was conducted under the approval of the Ministry of the Environment with the intention that the emissions from this plant would meet Government regulations with regard to ambient air quality.

Prior to the opening of the zinc plant, fears had been expressed that widespread environmental damage might occur in the Timmins area as a result of the operation of the refinery. In order to determine the environmental impact of the air-borne emissions from this plant, the Ministry of the Environment developed a program to monitor the air quality, vegetation and soils in the area two years prior to the scheduled opening of the refinery. In 1970, a network of 10 study plots, with the zinc plant as the focal point, was established ranging up to 32 kilometres from the plant. In addition, two control plots each 80 km from the plant were established.

After studying the data available since 1970, this survey was re-aligned in October, 1973. At that time, several of the more remote plots were discontinued and several new plots were established closer to the source. Also, in the 1973, 1974 and 1975 growing seasons, close attention was given to the vegetation and soils in the immediate vicinity of the refinery complex. A snow sampling program was initiated in the winter months of 1974 and repeated during the winter of 1975 and 1976. A program to assess the role of railroad transportation of metal ore concentrates was initiated in 1975. This program included vegetation and soil sampling in the vicinity of the railroad tracks during the growing season and continued as part of the snow sampling program in 1976.

In 1975, Texasgulf Incorporated announced plans for expansion of their Timmins operations. This expansion could include a copper smelter and refinery, a lead plant, a fertilizer plant and possibly a cement plant. The Company is working closely with the Ministry of the Environment on this program to insure that environmental deterioration will not result from the operation of this planned industrial complex. The Ministry will continue to monitor various environmental parameters in order to evaluate the performance of both new and old installations.

This report outlines the available data collected in the Ministry of the Environment surveillance programs conducted in the vicinity of the Texasgulf operation.

II VEGETATION AND SOIL MONITORING:

A. Plot Establishment:

During the growing season of 1970, ten surveillance plots and two control plots were established in the Timmins area by the Ontario Ministry of the Environment (1). A program of sampling the vegetation and soil at each established plot was initiated. Leaf samples from trembling aspen, white birch, alder (or substitute), white spruce, forage, soil and water were collected and analysed for fluoride, total sulphur, arsenic, cadmium, iron and zinc. In June, July and August, 1971, this program was expanded to add jack pine, white spruce and beaked hazel (or substitute) to the sampled materials. These samples were analysed for total sulphur, silver, arsenic, cadmium, copper, iron, lead and zinc. In 1972 and 1973, this sampling was repeated in June, July and August and the samples were similarly analysed.

Examination of the data obtained from 1970 to 1973 indicated that the environmental impact of the refinery with regard to vegetation and soils was localized in the vicinity of the zinc plant and that widespread problems were not being encountered. These facts resulted in a re-alignment of the surveillance program for the 1974 season. Accordingly, several plots were discontinued and 4 new plots were established in closer proximity to the zinc plant in October, 1973. In May, 1974, a new control plot was established approximately 32 kilometres west-southwest of the zinc plant. Also the plot (old Plot 1) 1.6 km E was destroyed by logging (1973) and was replaced.

The plot numbers and locations with relation to the zinc plant are as follows:

<u>Plot Number</u>	<u>Distance and Direction From the Zinc Plant</u>
1	0.8 km ENE
2	2.2 km ENE
3	3.2 km NE
4	8.0 km NE
5	16.1 km NE
6	8.0 km E
7	16.1 km E
8	0.8 km SW
9	1.6 km SW
10	16.1 km SW
11	32.2 km WSW

(See Appendix for map (Figure 1) and plot locations and site descriptions)

As in the original plots, 20 trembling aspen trees and 10 shrubs were tagged. The crown condition, height and diameter of each tree was recorded for use in growth studies.

In 1975, the replacement plot 1 was again replaced by a new plot since it had been destroyed in the expansion of the refinery complex. The current plot is location .8 km ENE of the zinc plant. Also, in 1975, a plot (8A) was established 1.2 km SW of the zinc plant on a contingency basis since a possibility exists that plot 8 will be destroyed if the buffalo compound is enlarged.

B. Vegetation Sampling:

Since the data base for the levels of several chemical elements in vegetation had been established from earlier work the vegetation sampling program in 1974 was reduced to include only the foliage of trembling aspen, white spruce and forage. These samples were analyzed for sulphur, cadmium, chlorine, copper, iron, lead and zinc. In 1975, triplicate samples of trembling aspen foliage were collected at each plot. These were analyzed for zinc, copper, lead, cadmium and arsenic. Vegetation sampling was completed in July and in August in both 1974 and 1975.

C. Soil Sampling:

In 1974, soil samples were collected from three depths at each location ((0-5 cm, 5-10 cm, and 10-15 cm) and analyzed for sulphur, cadmium, chlorine, copper, iron, lead, zinc, calcium, magnesium and pH. Triplicate samples from three depths were collected at each plot in 1975, and analyzed for zinc, copper, lead, cadmium, calcium, magnesium and arsenic. Soil samples were collected in July and August during 1974 and 1975. In 1974 and 1975 soil samples were also collected at the site of the original plot 1 (1.6 km E).

D. Tree Condition and Growth Studies:

The crown condition of each tagged tree in the vegetation plots was recorded at each visit during the growing season in 1974 and 1975. The presence of air contaminant injury and insect injury was also recorded at each visit. In 1975 the severity of insect injury was rated on the following arbitrary scale;

<u>Rating</u>	<u>Severity</u>	<u>% Foliage Damaged</u>
1	None to trace	0-5
2	Trace-light	5-10
3	Light	10-20
4	Light-Moderate	20-30
5	Moderate	30-40
6	Moderate-Severe	40-60
7	Severe	Over 60

The presence of Fomes heart rot and Hypoxylon canker, (both fungal diseases) was also recorded. At the end of each growing season the height and diameter of each tree was measured. The average growth rate of trees in each plot was computed as the increase in diameter per year. At plot 5, the presence of Hypoxylon cankers on the tree trunk caused distortion of the bark, therefore the data are reported for non-cankered trees only.

E. Snow Sampling:

A program of snow sampling was established at several locations around the zinc plant during the 1974 winter months. The

program was continued in 1975 and 1976. Data for the 1974 and 1975 collections has been presented in a previous report(2) and the results of the 1976 collection have not yet been completed.

OBSERVATIONS:

F. Chemical Analysis Results for Vegetation:

Chemical analysis of samples collected in 1974 and 1975 have been completed and the results are presented in Tables 2 to 9. The results show that the concentrations of all elements are within the normal concentration range for trembling aspen foliage at all locations with the exception of plot 1 and old plot 1. At plot 1 zinc, copper, lead, cadmium, arsenic and iron concentrations in foliage are elevated above the concentrations encountered at the control location. Concentrations of zinc at old plot 1 are also higher than background. A year to year increase in zinc, copper, lead, cadmium and iron at these same two plots can be seen. Yearly increases of zinc and cadmium at plot 3 are possibly related to the proximity of the sampling location to the railroad. Further studies to clarify the contribution of the railroad source to the environment are currently in progress.

G. Chemical Analysis Results for Soil:

The results of chemical analysis of soil samples collected in the Timmins area during 1974 and 1975 are presented in Tables 10 to 17. The concentration of zinc, copper, lead, cadmium and arsenic are greatest nearest to the surface of the soil. The reverse pattern exists for iron which is leached downward in the soil profile and is present at higher concentrations greater depths.

The highest concentrations of zinc, copper, lead, cadmium and arsenic are found at the plot sites nearest to the zinc refinery. Plot 1, .8 km ENE consistently had the highest concentrations, while soils at old plot 1, 1.6 km E and plot 8, .8 km SW had the next highest concentrations of these metals.

H. Results of Tree Conditions and Growth Studies:

During 1974, the first record of injury to the vegetation located on the study plots was recorded. Sulphur dioxide injury occurred to the trees, shrubs and herbaceous plants on plot #1 (0.8 km ENE of the zinc plant). Injury also occurred to vegetation located in the vicinity of old plot 1. This injury was noted in the previous annual report. No visible, acute, vegetation injury, which could be ascribed to the effects of air pollutants, was found at any of the remaining plots. Various insect pests and plant pathogenic fungi were found to be causing injury to several plant species at many of the plots. However, most of these problems were minor in nature.

No acute air contaminant injury to vegetation was noted at any of the study plots in 1975. Insect injury was common at all plots and increased in severity each month (Table 1). Fomes heart-rot was noted on several trees however there were a greater number of trees infected with Hypoxylon canker. Seven trees at plot 5 were

infected with Hypoxylon canker and will be replaced with healthy trees.

The crown condition of trees has been recorded each year. The crown condition classification system employed was modified from the system developed by the Canadian Forestry Service for hardwood species in Ontario. A classification gradation from 1A (healthy) to 6B (dead), with several intermediate conditions, allowed for an informative description of the crown condition at the time of surveillance.

Table 1 includes a list of the number of trees which have died or had crown conditions decline or improve in each plot since it was established. The mortality and decline rates at the surveillance plots were similar to that of the controls. The number of dead or declining trees on all plots represents 10.0% of the total number of tagged specimens. Therefore 90.0% of the trees and shrubs either maintained their position or showed improvement.

Growth measurements for the trembling aspen trees indicated that the majority of trees were showing normal height and diameter increments each year (Table 1). The data indicate that diameter growth for the surveillance plots compares very favourably with that at the control plots.

I. Results of Snow Sampling:

The results of snow sampling studies carried out in 1974 and 1975 have been presented in a previous report (2). The data indicate that the levels of sulphate, cadmium, lead and zinc are elevated near the zinc plant and that concentrations of these elements decrease rapidly with distance from the plant. Chemical analysis of snow samples collected in 1976 had not been completed at the time of writing this report.

CONCLUSIONS:

The results of the vegetation and soil sampling program indicate that a build-up of zinc, copper, lead, cadmium and arsenic is occurring in both soil and vegetation within 2 km of the refinery complex. The growth rate of trembling aspen trees is normal in the surveillance plots at present however a problem exists with insect and disease injury occurring on many trees.

III. AIR QUALITY MONITORING:

A. Introduction:

In January, 1971, the Ministry of the Environment initiated a program to monitor the ambient air quality in the Timmins area in order to determine the environmental impact of air-borne emissions from the Texasgulf Refinery operations near Hoyle.

At that time a total of twelve lead peroxide candles were installed at distances of 1.6 to 80 km from Hoyle in order to determine the levels of sulphur dioxide in the ambient air. This initial survey was modified in 1973 as a result of the findings in 1971 and 1972. Consequently some of the more distant candles were relocated closer to Hoyle. The present sulphation survey comprises eleven lead peroxide candles set out at the locations shown in Figure 1. A more detailed illustration of the Texasgulf Zinc Plant appears in Figure 2.

As part of the expansion in the ambient air quality monitoring program, a high volume sampler was installed in June, 1972 in the vicinity of Ecstall Mining Limited near Hoyle for the purpose of monitoring concentrate dust blowing from standing, loaded railroad cars. Initially the sampler was located on the north side of Highway #101, near the railway as shown in Figure 2.

In March, 1973, the high volume sampler was relocated on the east side of Highway #610 approximately four hundred metres north of Highway #101. This was necessary as Texasgulf acquired the property on which the sampler was originally located.

Also in March, 1973, a dustfall jar was set up on the west side of Highway #610 as indicated in Figure 2.

B. Analysis of Dustfall:

The results of the dustfall measurements for 1975 appear in the table below. The data for November and December were not available when this report was written. The dustfall jar is left exposed to the atmosphere for a period of thirty days. The weight of the particulate matter that settles in the container is measured and the amount of dustfall collected is expressed as tons/square mile/30 days.

<u>Month</u> <u>(1975)</u>	<u>Amount of Dustfall</u> <u>(tons/sq.mile/30 days)</u>
January	5
February	6
March	7
April	12
May	19
June	23
July	24
August	21
September	29
October	3

The data indicate that the dustfall levels were considerably higher during the summer months. Figure 4 clearly demonstrates the variation in dustfall levels with the time of the year. Furthermore this dustfall jar is located near a section of Highway #610 that is heavily travelled by dump trucks. Hence this heavy traffic could possibly be the reason for the higher levels during the summer months.

In the ten month period, ie: from January to October, the levels of dustfall exceeded the Ontario Criterion of 20 tons/sq.mile/30 days on four occasions. The highest amount of dustfall occurred in September.

The data for total dustfall for 1973 and 1974 were also compiled together with the 1975 data as shown in the table below.

Year	Number of Samples	Annual Mean (tons/sq.mile/30 days)	Number of Times Above Criterion*	
			1 Month	1 Year
1975	10	15	4	1
1974	8	15	2	1
1973	6	10	Nil	Nil

* Ontario Criterion: - Monthly - 20 tons/sq.mile/30 days.
- Annual - 13 tons/sq.mile/30 days.

The means for 1975 and 1974 exceeded the annual criterion by 2 tons/sq.mile/30 days and were significantly higher than the mean for 1973. It should be pointed out that only six samples were available in 1973 for the determination of the average. In 1973 the criterion for total dustfall was not exceeded, whereas the monthly criterion was exceeded twice in 1974.

In 1975, the contents of the dustfall jar were also analyzed for the presence of arsenic, copper, cadmium, iron, lead, nickel and zinc. The results are expressed as weight percent of the total dustfall. Data for the months of July, August and September were available at this time.

Element	July	August	September
As	.00	.00	.00
Cu	.09	.10	.02
Cd	.00	.01	.00
Fe	2.03	2.74	.36
Ni	.01	.02	.01
Pb	.04	.04	.01
Zn	.83	.92	.49

Iron, zinc, copper and lead accounted for the largest fraction of the above elements in the total dustfall; the higher fractions consisting of iron and zinc. The fractions of the total dustfall of iron, zinc, copper and lead decreased substantially in

September suggesting that the higher levels of dustfall reported for that month, as indicated earlier, probably resulted from higher levels of road dust as blowing silicates.

C. High Volume Sampling:

The concentration of suspended particulate matter in the air, ie: the solid particulate matter that either takes a very long time to settle to the ground or does not settle at all owing to its very small mass, is determined by a high volume air sampler. This instrument draws approximately 1.5 cubic metres of air per minute through a preweighed filter medium.

The increase in weight of the filter then determines the amount of suspended particulates deposited. The results are expressed as micrograms per cubic metre ($\mu\text{g}/\text{m}^3$) of air sampled. The sampler is operated continuously for a 24 hour period every sixth day resulting in four to five samples per month.

In addition to total loading, the filter can also be analyzed for the presence of several elements by atomic absorption.

In 1975, the filters from the high volume air sampler located near Hoyle were analyzed for total loading and also for the following elements: arsenic, cadmium, copper, iron, lead, nickel and zinc. The data are shown in Tables 18 and 19 of the appendix.

A total of thirty-five samples were collected for particulate loading over the ten month period from January to October. From Table 18 it can be seen that the 24-hour criterion for suspended particulates was exceeded on three occasions for that period of time. These high readings were recorded on June 18, September 23 and 29; the levels on those days were 135, 127 and 184 $\mu\text{g}/\text{m}^3$ respectively. The geometric mean for all 1975 samples was 42 $\mu\text{g}/\text{m}^3$, well below the O.M.E. annual criterion of 60 $\mu\text{g}/\text{m}^3$.

A summary of the data for 1973 to 1975 appears in the table below. The dates in parentheses are those on which the maximum readings were recorded.

Year	No. of Samples	Geometric Mean ($\mu\text{g}/\text{m}^3$)	Max. 24 Hr Reading ($\mu\text{g}/\text{m}^3$)	No. of Times Above Criterion	
				24 Hr.	1 Yr.
1975	34	42	184 (Sept.29)	3	Nil
1974	53	32	169 (July 16)	2	Nil
1973	31	36	80 (July 16)	Nil	Nil

In 1973, the O.M.E. criteria were not exceeded whereas the 24 hr. criterion was exceeded twice in 1974. The annual geometric mean was somewhat higher in 1975 but as indicated above was well below the criterion.

The distribution of the average monthly total loading for 1975, as illustrated in Figure 5, is similar to the variation of the dustfall levels reported earlier and illustrated in Figure 4. In both cases the levels were higher during the summer period, the highest value occurring in September.

The maximum recorded levels of the metallic elements over a 24 Hr. period are listed below with the O.M.E. criterion for each element.

Element	No. of Samples Analyzed	Max. 24 Hr. Value ($\mu\text{g}/\text{m}^3$)	O.M.E. Criterion For 24 Hr. ($\mu\text{g}/\text{m}^3$)	No. of Times Above Criterion
As	30	.015	25	Nil
Cd	14	.007	2	Nil
Cu	12	.71	50	Nil
Ni	12	.04	2	Nil
Fe	12	3.79	No Criterion	
Pb	35	0.57	5	Nil
Zn	31	3.97	No Criterion	

The levels of these metallic elements were well below the existing criteria. It should be noted that there is no criterion for Fe and Zn, for which the maximum 24 hr. values were significantly higher.

The average monthly values for the seven metallic elements were plotted as shown in Figure 6 and 7. As was the case for total dustfall, iron, zinc, copper and lead account for the largest fraction of the total loading for the elements investigated. Of significance are the higher levels of iron, zinc, cadmium, copper and lead in the month of September. This could explain the higher level of suspended particulates in September as illustrated in Figure 5. Closer inspection of the data for the months of August, September and October indicated that these elements comprised only 5.6%, 4.0% and 6.5% of the total loading respectively. This means that, as was the case for dustfall measurements, the higher levels recorded in September consisted principally of suspended particulates from road dust.

D. Sulphation Rates:

The data for sulphation rates during the growing season are presented in Table 20 of the appendix. The values were all well below the O.M.E. criterion of $0.7 \text{ mg SO}_2/100 \text{ cm}^2/30 \text{ days}$. Only one candle (0.8 km ENE of Hoyle) showed elevated levels in the rate of sulphation in August and September. In both instances however, the values were well below the criterion for desirable ambient air quality.

As in previous years, the sulphation data for 1975 in the Timmins area indicated that only background levels of sulphur dioxide were present in the ambient air.

E. Conclusions:

From the dustfall and suspended particulate results it can be concluded that most of the particulates consisted of material originating from dump truck activity on Highway #610. This dust is most likely siliceous in nature. This is borne out by the fact that the seasonal variation in the amount of dustfall and suspended particulates is not apparent for the selected elements investigated. Furthermore, the higher levels of these elements (As, Cd, Cu, Ni, Fe, Pb and Zn) in September cannot account for the significantly higher levels in total dustfall and suspended particulates for that month.

In 1975, the O.M.E. criterion for dustfall was exceeded on four occasions during the ten month period. For this same period, the annual criterion was also exceeded.

The 24 hr. criterion for suspended particulates was exceeded on three occasions during 1975. This represents an increase over the previous year when the number of samples was greater.

As in previous years, only background levels of sulphur dioxide were present in the ambient air in the Timmins area in 1975.

IV. RAILROAD STUDIES:

Methods:

In June, 1975, a program was established to determine the importance of concentrate-loaded railroad cars as a source of heavy metal contamination. In previous years the Ministry of the Environment had received several complaints concerning wind-blown concentrates from stationary railroad cars on a railroad siding immediately east of the zinc smelter complex. Six sites were selected along the railroad tracks north-east of Hoyle. Two of these sites were in close proximity to the railroad siding in question. The locations of the sampling sites are shown in Figure 3.

At each site triplicate samples each of raspberry foliage and soil from three depths (0-5, 5-10 and 10-15 cm) were collected at 0, 50 and 100 metres from the railroad property line. All samples were collected on the south-east side of the railroad tracks. All samples were analyzed for zinc, copper, lead, cadmium, iron and arsenic.

Observations were made on the condition of vegetation at Railroad Site 1 in July and August, 1975. At this site samples of trembling aspen and raspberry were collected for chemical analysis in July and samples of a number of vegetation species were also collected for herbarium and histological examination.

Observations and Results:

The vegetation at all sites appeared to be healthy at all locations in the Railroad survey at the time of sampling on June 25-26, 1975. On July 23, 1975, vegetation in the vicinity of Site #1 of the Railroad study was examined. No injury to vegetation which could be attributed to air contaminants was observed except within 5 metres of the railroad tracks. Within this area vegetation was observed to have spots of a light grey particulate material on the surface of the foliage. Injury was not directly associated with the particulate material but appeared to be related to a systemic condition. Sedge, *Diervilla lonicera*, and serviceberry showed only particulate on the surface. Leaves of raspberry were frequently chlorotic with intercostal anthocyanosis. Aster foliage showed anthocyanosis of terminal and marginal areas. Buckwheat plants were extremely red anthocyanotic. Similar grey particulate material was observed on the railroad ties and rails.

The concentrations of metals in the vegetation collected at site 1 are reported in Table 21. The concentrations of Zn, Cu, Pb and Cd are highly elevated in all collections. The concentrations of metals increased in raspberry between the June and July collections.

Vegetation in the vicinity of Railroad Study Site 1 was again examined on August 27, 1975. The light grey particulate previously observed on the foliage of plants within 5 metres of the railroad track was not present at the visit and in all probability had been washed from the leaves by rain. Several plant species showed injury symptoms. The symptoms were as follows:

<u>Plant Species</u>	<u>Injury Symptoms</u>
Raspberry	- light-moderate marginal chlorosis and/or light-moderate marginal necrosis, frequently with strong anthocyanosis.
Elderberry	- light marginal necrosis, light marginal and intercostal chlorosis.
Serviceberry	- some plants severely defoliated with several marginal necrosis.
Aster	- trace-light marginal anthocyanosis; some protected leaves with grey particulate in cupped portions.
Fireweed	- variable, leaf spotting, marginal and intercostal chlorosis.
Willow	- tar spotting (fungal disease)
Cattail	- light-moderate terminal necrosis preceded by chlorosis.

The highest concentrations of zinc, lead, cadmium and arsenic in raspberry foliage were recorded at sites 1 and 2 which are associated with the stationary railroad cars loaded with concentrates. (Table 22) Copper concentrations also fit this pattern with the exception of one sample at Site 3 (50 m). A tendency for concentrations of these elements to decrease with distance from the railroad was noted at several locations, however, this could not be demonstrated statistically. The limited availability of material for sampling is considered to be responsible for the difficulties encountered with the statistical analyses (Table 23).

The concentrations of zinc, copper, lead, cadmium and arsenic in soil were found to be greatest near the railroad track and decreased with distance from the railroad track (Tables 24 to 29). These elements were also found to be present in the highest concentrations in the upper 5 cm of soil and decreased with depth (Table 30). At sites 1 and 4, the metal content of the soil was extremely elevated, particularly in the case of zinc. Iron concentrations in the soil samples did not form any evident pattern with soil depth or distance from the railroad tracks. Sites 3 and 5 which have the lowest concentrations of iron are the same sites which showed the lowest concentrations of lead. The site 2 at 50 m from the tracks is regarded as an anomolous site with regard to arsenic.

Conclusions:

High concentrations of zinc, copper and cadmium were found in surface soils close to the railway. The high concentrations associated with site 1 and to a lesser extent, site 2, can be attributed to losses of concentrate from the stationary railroad cars at those locations. Site 4, which had the highest recorded concentrations of zinc is more difficult to explain since the railroad cars are not expected to be stationary at this point, at least on a regular basis. By comparison, the concentrations of zinc at sites 3, 5 and 6 are lower than at the other railroad study sites but are noticeably higher than in comparable soils slightly removed from the railroad.

Elevated concentrations of zinc, copper, cadmium and arsenic in raspberry foliage were found at sites 1 and 2 which are associated with the area where railroad cars, loaded with concentrates are allowed to remain stationary for extended periods.

V. SPECIAL SURVEILLANCE:

A. Methods:

Considerable injury to a number of plant species was noted during the 1973 growing season and again during 1974 in the immediate vicinity of the zinc plant, mainly on company property. During a preliminary inspection in July, 1973 several different injury patterns were recorded on many plant species. In July, 1974, extensive injury similar to that found in 1973 was recorded on raspberry, jewelweed, elderberry, fireweed and bindweed. This injury was noted mainly to the south and south-west of the zinc plant. In August, 1974, a more complete survey was conducted in the immediate vicinity of the zinc plant recording injury to vegetation and collecting soil and vegetation for chemical analysis. Vegetation injury similar to that observed in July was more intensive in August and covered a wider area, although the injury was still mainly restricted to the open stretches along the edge of wooded areas. Injury was noted to the northwest, west, southwest, and south of the zinc plant.

The chemical analysis results for soil and vegetation samples collected in the special surveillance program in 1973 and 1974 indicate that contamination of both types of samples by zinc, copper, lead and cadmium was occurring in close proximity to the zinc refinery. These results have been included in a previous report (2).

The vegetation in the area in close proximity to the zinc refinery was examined during each monthly visit to the Timmins area in 1975. Injury was again observed in the area and was found to be greatest approximately 100 m S of the zinc remelt furnace stack area. Triplicate samples of trembling aspen and soil were collected in this area for chemical analysis. Samples of a number of species were also collected for herbarium purposes and histological examination.

B. Results and Observations:

Injury symptoms observed on vegetation in the vicinity of the zinc refinery in 1975 were similar to those encountered in 1974. Symptoms were slightly more severe on July 22 than on June 26, 1975. The condition of various species of vegetation noted in July at the site 100 m S of the zinc remelt furnace are noted below:

<u>Species</u>	<u>Symptoms</u>	<u>Degree</u>
Dandelion	-brown intercostal necrosis	-severe
Aster	-leaf cupping, anthocyanosis, marginal necrosis	-light-moderate
Prairie Willow	-intercostal chlorosis and anthocyanosis	-moderate on one bush
Fireweed	-leaf spotting and marginal necrosis	-moderate
Trembling Aspen	-chlorosis, marginal necrosis	-light
Fern (<u>Botrychium</u>)	-overall chlorosis, marginal necrosis	-light
Dewberry	-marginal anthocyanosis	-light

(con't) <u>Species</u>	<u>Symptoms</u>	<u>Degree</u>
<u>Lonicera</u>	-brown intercostal necrosis	-severe
<u>Alder</u>	-intercostal necrosis	-light-moderate on older leaves
Gooseberry	-terminal necrosis, anthocyanosis	-trace-moderate
<u>Clintonia</u>	-terminal necrosis, overall chlorosis	-light
Aster	-leaf spotting (fungal)	-light
Raspberry	-intercostal and marginal necrosis, anthocyanosis	-light
Red Ozier Dogwood	-intercostal necrotic spots deformation of leaves	-light
Goldenrod	-no injury	
White Birch	-no injury	
Vetch	-no injury	

The vegetation in the area was examined again on August 27, 1975. Some injury similar to that observed in the July visit was present. The symptom patterns however, were confused as a result of herbicide spraying of the vegetation along the railroad. The injuries noted on the vegetation were attributed to a combination of herbicide injury, refinery related operations and biological agents. No such injuries have been noted on the same species at any of the surveillance plots. The symptoms noted on vegetation species 100 m S of the zinc remelt furnace at the time of the August investigation are listed below:

<u>Species</u>	<u>Symptoms</u>	<u>Degree</u>
Balsam Poplar	-terminal & marginal necrosis, defoliation	-severe
Elderberry	-overall chlorosis, marginal necrosis, marginal shattering	-light
Red Ozier Dogwood	-intercostal anthocyanosis	-moderate
Willow	-marginal and intercostal pathogenic spots	-severe
Aster	-white speckle; purple spotting	-light
Pearly Everlasting	-terminal necrosis (near track)	-severe
<u>D. Lonicera</u>	-terminal necrosis (near track) with intercostal and scabby surface	-severe
Vetch	-necrosis with regeneration of foliage	-severe
<u>Lonicera</u>	-defoliation and regeneration of foliage	-severe
Rose	-anthocyanosis, necrotic spotting; chlorosis of old leaves	-moderate
Golden Rod	-marginal necrosis, spotting	-moderate
Alder	-marginal necrosis	-moderate
Grass	-chlorotic regeneration among dead foliage	-severe
<u>Botrychium</u>	-terminal necrosis	-severe
<u>Dandelion</u>	-white speckle on exposed surface leaf spot, anthocyanosis, epinasty, regeneration among dead foliage	-light

The chemical analysis results of vegetation and soil samples collected 100 m S of the zinc refinery are presented in Table 31. Concentrations of zinc, copper, lead and cadmium in trembling aspen are all elevated above concentrations present in samples collected at the control site. These same elements are also elevated in the soil at 100 m S of the zinc refinery. The highest concentrations are present in the surface soil layer.

C. Conclusions:

High concentrations of zinc, copper, lead and cadmium are present in soil and vegetation in close proximity to the zinc refinery. Injury to vegetation in the area 100 m to the south of the zinc refinery has been present in each of the growing seasons of 1973, 1974 and 1975.

VI. SUMMARY AND CONCLUSIONS:

In 1970, the Ontario Ministry of the Environment initiated a pre-operational background survey of the environmental situation in the Timmins area where Ecstall Mining Company was expected to construct an electrolytic zinc refinery near Hoyle (20 km NE of Timmins). The refinery was erected adjacent to the ore concentrator which had been operative since 1966. This new zinc plant became operational in April, 1972. From 1970 to 1975, Ministry personnel have conducted an extensive program of environmental analysis and evaluation in the area.

The ambient air quality monitoring program has shown that dustfall levels are frequently elevated in the vicinity of the zinc plant. The levels of suspended particulates are usually below the objective for acceptable ambient air quality, although the 24 hr. criterion was exceeded on three occasions during 1975. The sulphation rates indicated that only background levels of sulphur dioxide were present in the ambient air in the Timmins area.

Chemical analysis of vegetation has shown that elevated levels of zinc, copper, lead and cadmium are present in the immediate vicinity of the zinc plant. Injury to vegetation in close proximity to the plant was observed in 1974 and 1975. No reduction in the rate of growth of trembling aspen trees at the surveillance plots could be detected however insect and disease problems were present on these trees.

The soil and vegetation sampling program in the vicinity of the railroad has implicated the railroad as a source of environmental contamination by several metals. A decrease in concentrations of these metals with soil depth and distance from the railroad was observed.

The Ontario Ministry of the Environment will continue to monitor various environmental parameters in the Timmins area to ensure that the emissions from the operation meet Government regulations with regard to ambient air quality.

VII. ACKNOWLEDGEMENTS:

The author wishes to express his thanks to:
Mr. W. J. Gibson, Manager, Technical Support Section and Dr. D. Balsillie, Chief, Air Quality Assessment for supervision, advice and support; Dr. S. N. Linzon and staff of the Phytotoxicology Section, Air Resources Branch for technical advice and handling of the vegetation and soil samples; Mr. A. C. Rayner and the staff of the Air Quality Laboratory for chemical analysis of the vegetation and soil samples (Mr. R. Wills), and for analysis of lead peroxide candles, dustfall jars and hi-volume filters (Mr. M. Metzger and Dr. B. Foster), Mr. K. Waldie for maintenance of air quality sampling equipment; Mr. C. Gibson for exchanging hi-volume filters; Mr. R. Potvin for assembling the air quality data; Mr. B. Chai for the statistical analysis of the data; Mr. P. McGovern and many student-assistants over the years who assisted with field work and Mrs. J. Hatton and Mrs. L. Zuliani for secretarial assistance. As a result of the co-ordinated effort of all these people, the presentation of this report was made possible.

VIII. BIBLIOGRAPHY:

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- A P P E N D I X -

Plot Locations and Site Descriptions
(1974-1975)

Plot #1 Location:

.8 km East-N-East of the zinc refinery, north of the waterline easement and to the east of the concentrator complex in Hoyle Township.

Site Description:

Open aspen woods with a mixture of alder, spruce and balsam fir; shallow soil with numerous rock outcrops.

Plot #2 Location:

2.2 km East-North-East of the zinc refinery along an abandoned road which links Highways 101 and 610, east of the Porcupine River in Matheson Township.

Site Description:

Young aspen stand mixed with serviceberry and other shrubby species. The soil is deeper at this location compared to the other plots.

Plot #3 Location:

3.2 km northeast of the zinc refinery on the east side of Highway 610 in Matheson Township.

Site Description:

Open aspen stand on the edge of a black spruce wood. Trembling aspen is the dominant species with a speckled alder understory, and light ground cover. The soil is shallow, rocky and acidic.

Plot #4 Location:

8 km northeast of the zinc refinery on the south side of Highway 610 just east of Matheson Creek in Matheson Township.

Site Description:

Open aspen woods with a mixture of trembling aspen, balsam poplar and speckled alder with a dense ground cover.

Plot #5 Location:

16.1 km northeast of the zinc refinery on the east side of Highway 67 just north of the junction with Highway 610 in Dundonald Township.

Site Description:

Open aspen woodlot with trembling aspen dominant and an understory of alder and hazel.

Plot Locations and Site Descriptions
(1974-1975)

Plot #6 Location:

8 km east of the zinc refinery on the north side of Highway 101 just east of the Frederick House River in Matheson Township.

Site Description:

Trembling aspen dominant with a few scattered balsam fir and a ground cover of beaked hazel, mountain maple, with a few scattered speckled alder and pin cherry.

Plot #7 Location:

6.1 km east of the zinc refinery in Kettle Lakes Provincial Park in German Township.

Site Description:

Open dry, sandy jack pine woods with an aspen-alder mixture.

Plot #8 Location:

0.8 km southwest of the zinc refinery on the south side of the Ontario Northland Railway in Hoyle Township.

Site Description:

Open aspen woodlot with trembling aspen as the dominant species; with an alder understory; this is a poorly drained damp area.

Plot #9 Location:

1.6 km southwest of the zinc refinery, on the south side of Highway 101, along the road to the abandoned Falconbridge mine in Whitney Township.

Site Description:

Aspen stand with a thick understory dominated mainly by beaked hazel.

Plot #10 Location:

16.1 km southwest of the zinc refinery on the south side of Highway 101 just east of Schumacher in Tisdale Township.

Site Description:

Open aspen stand on a rocky slope with a speckled alder and balsam fir understory.

Plot Locations and Site Descriptions
(1974-1975)

Plot #11 Location:

32 km west-southwest of the zinc refinery on the east side of Highway 576, 4.5 km north of the Highway 101 in Godfrey Township.

Site Description:

Closed aspen woodlot with an understory of choke cherry and viburnum. Under the closed canopy a number of forest flora species make up the ground cover.

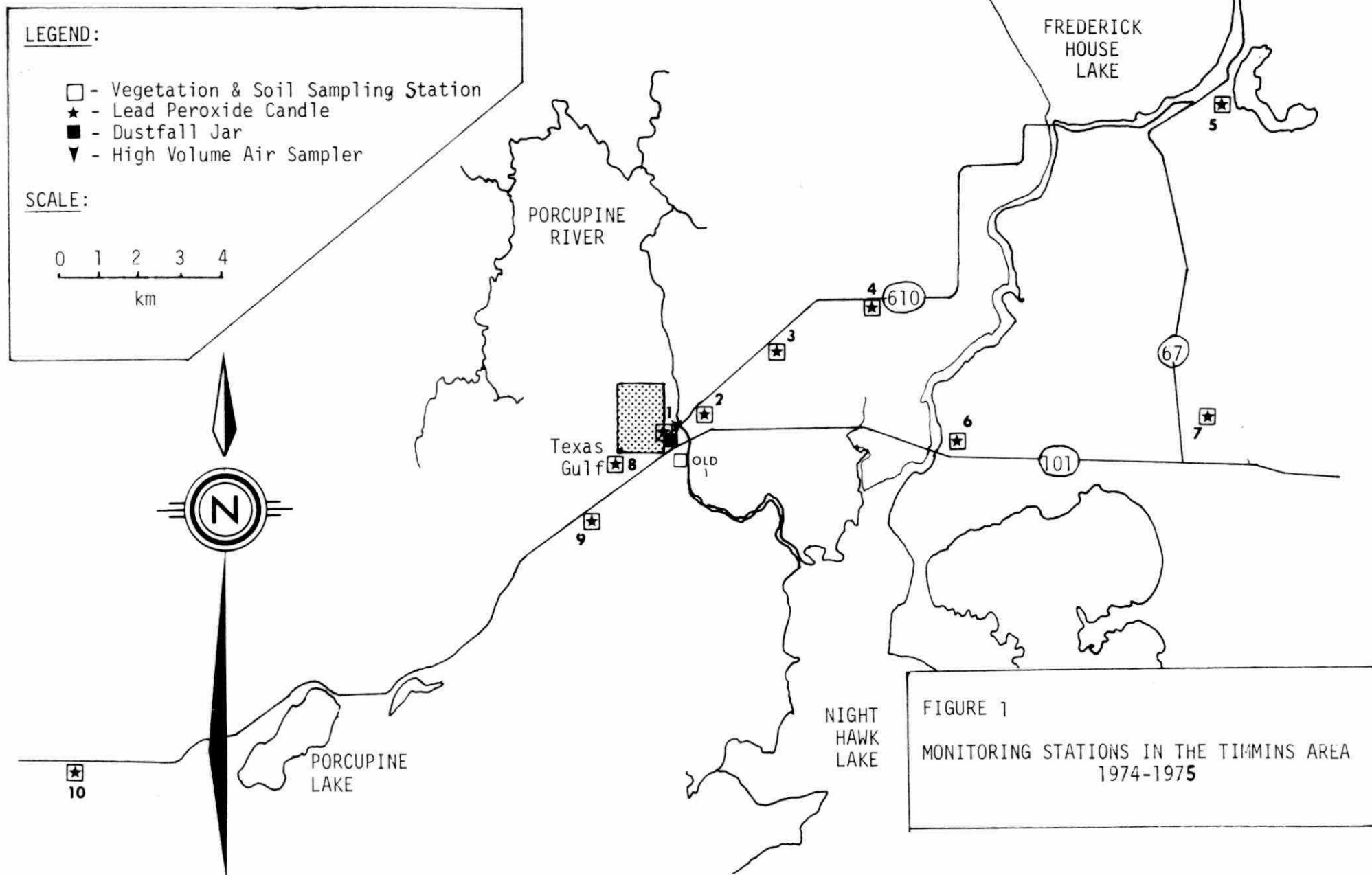


FIGURE 2

AIR QUALITY MONITORING STATIONS
IN THE VICINITY OF TEXASGULF SMELTER

TIMMINS - 1975

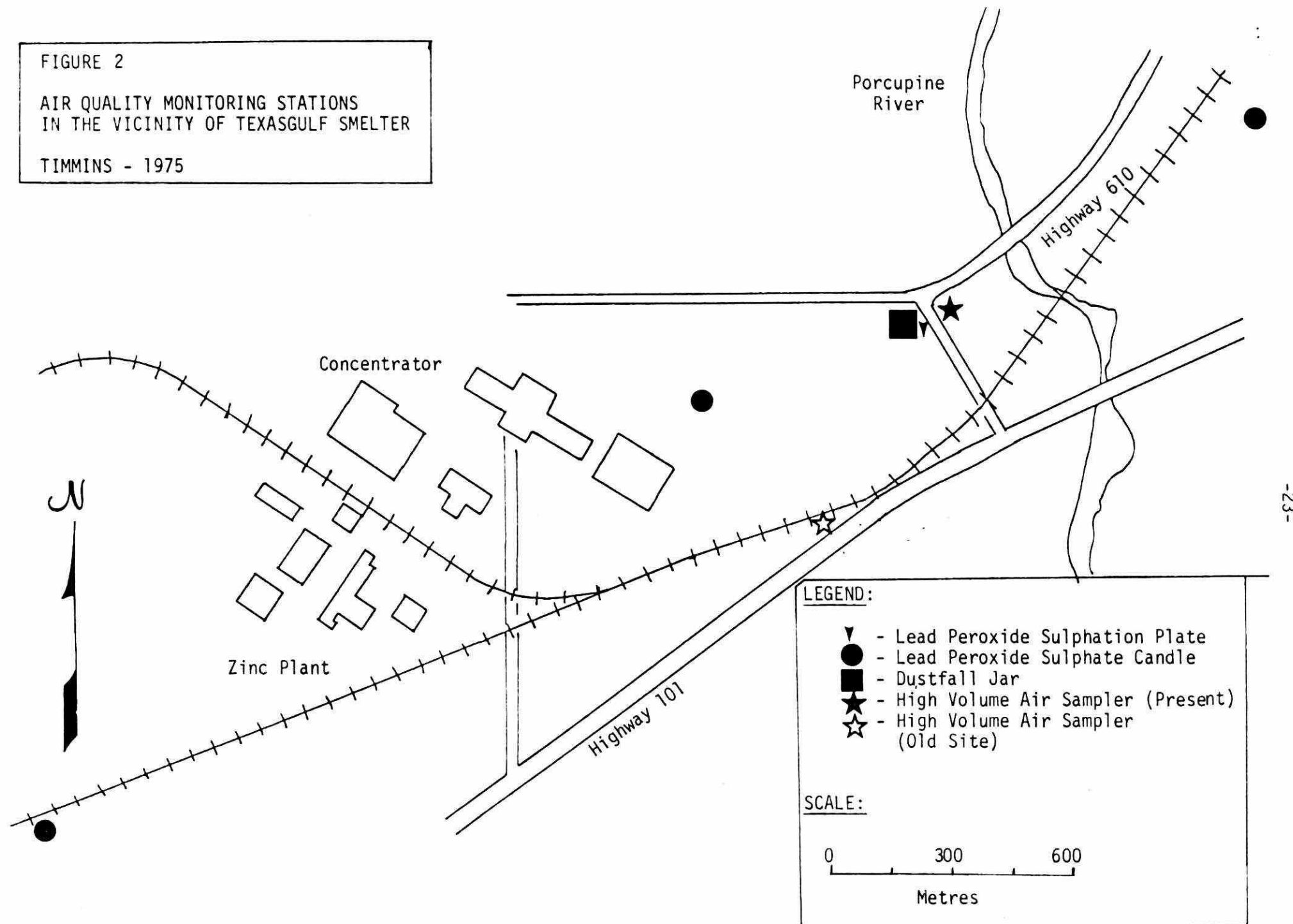


FIGURE 3

RAILROAD STUDY SAMPLING LOCATIONS

TIMMINS - JUNE 1975

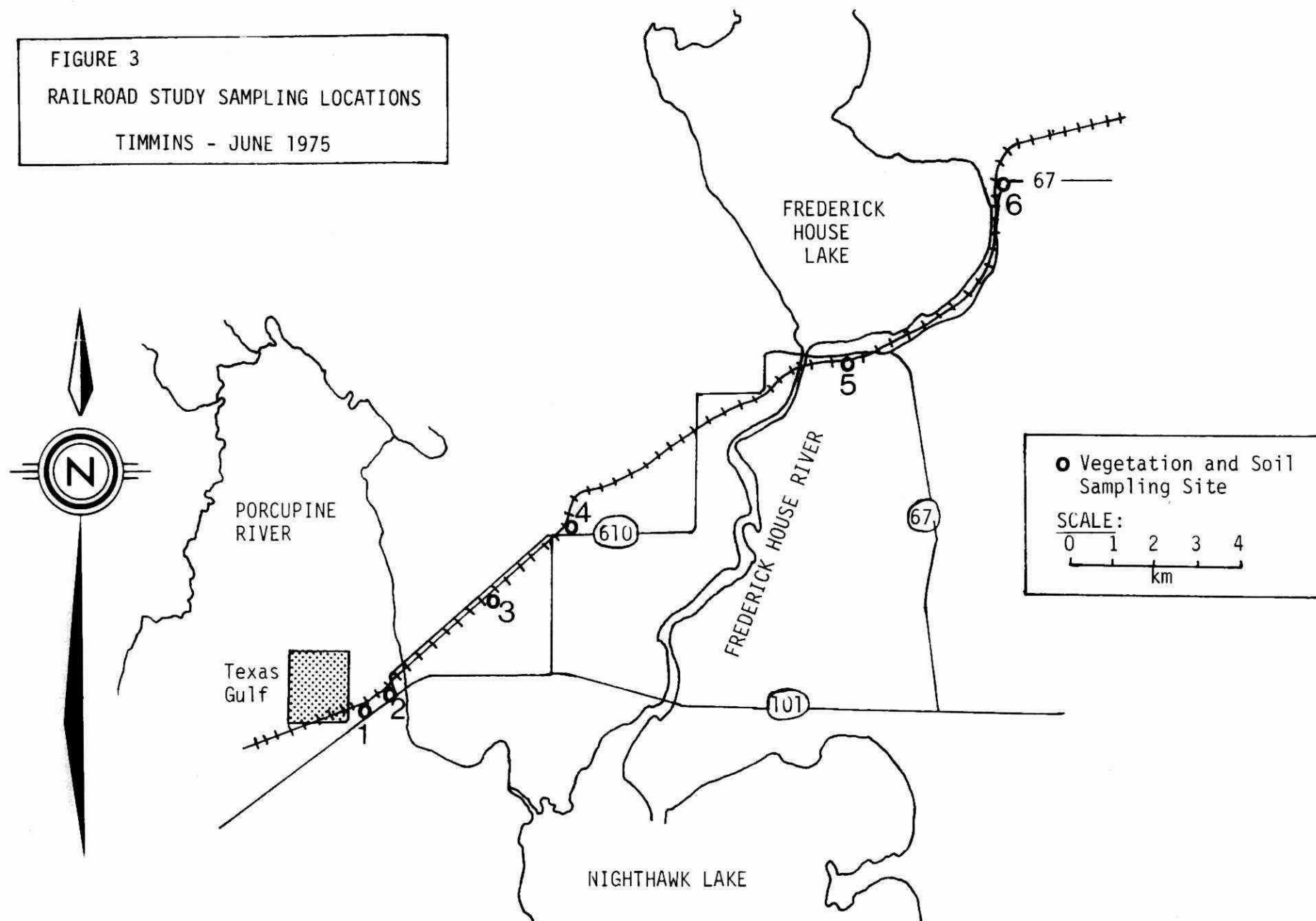
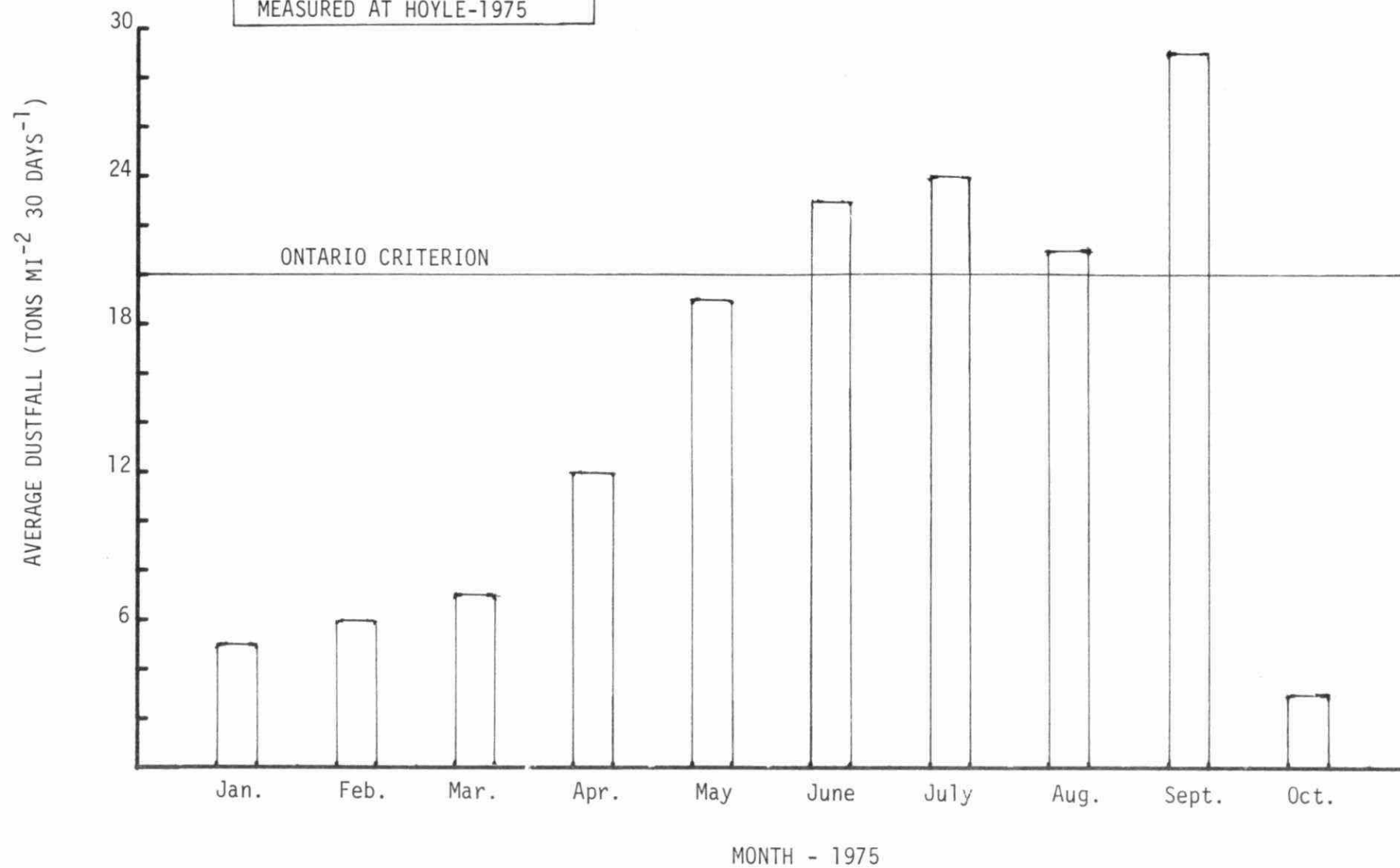
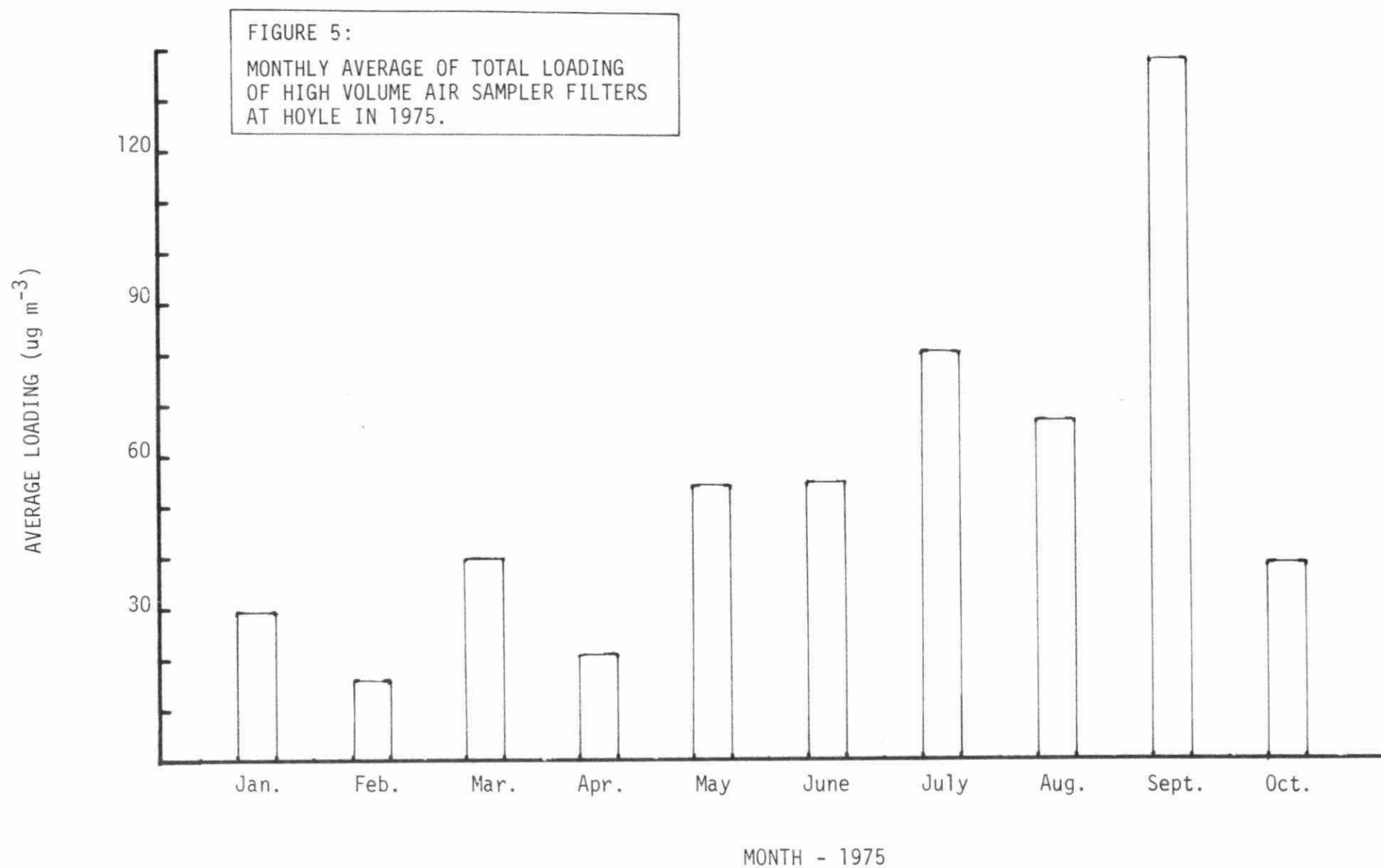
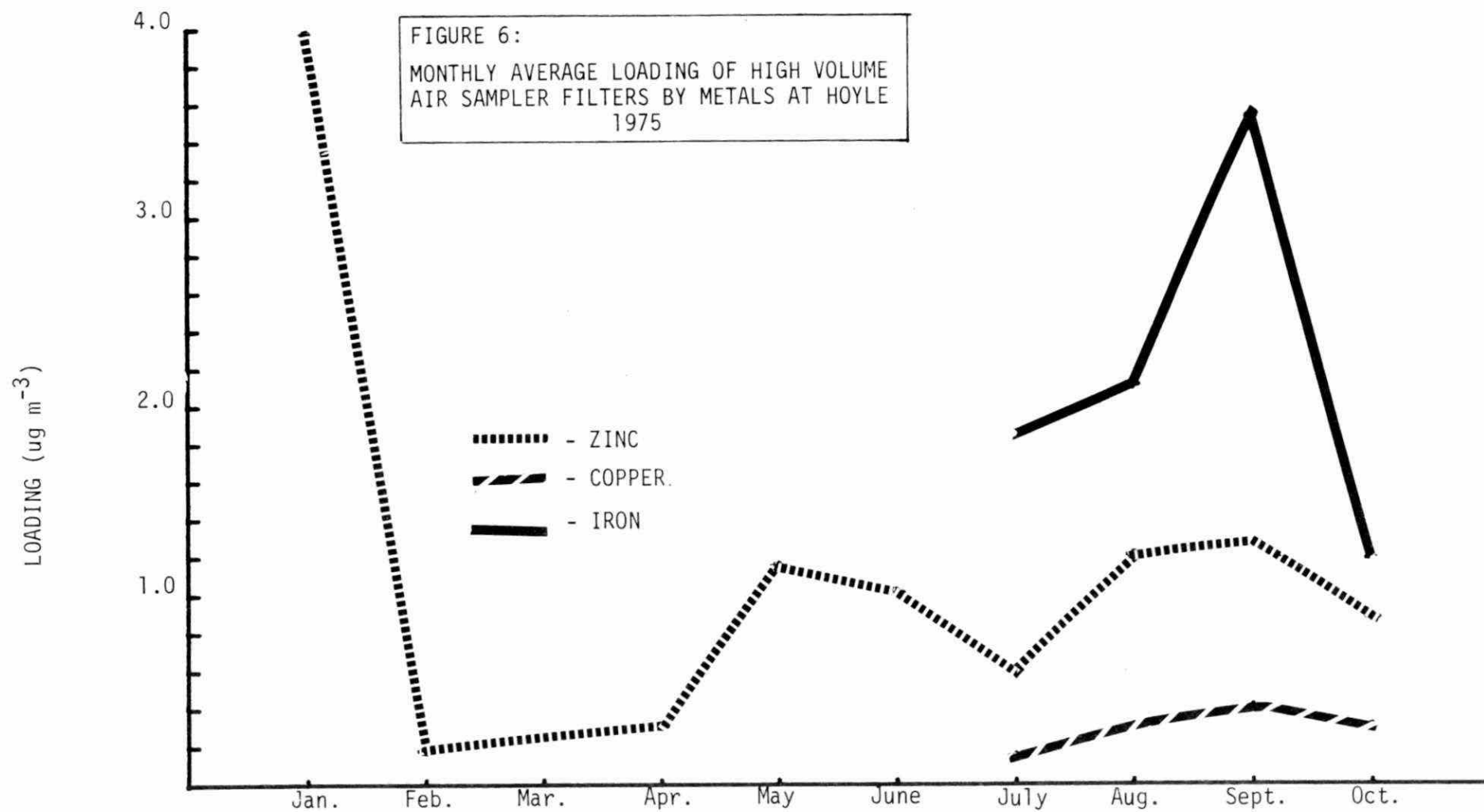


FIGURE 4:
MONTHLY AVERAGE DUSTFALL
MEASURED AT HOYLE-1975







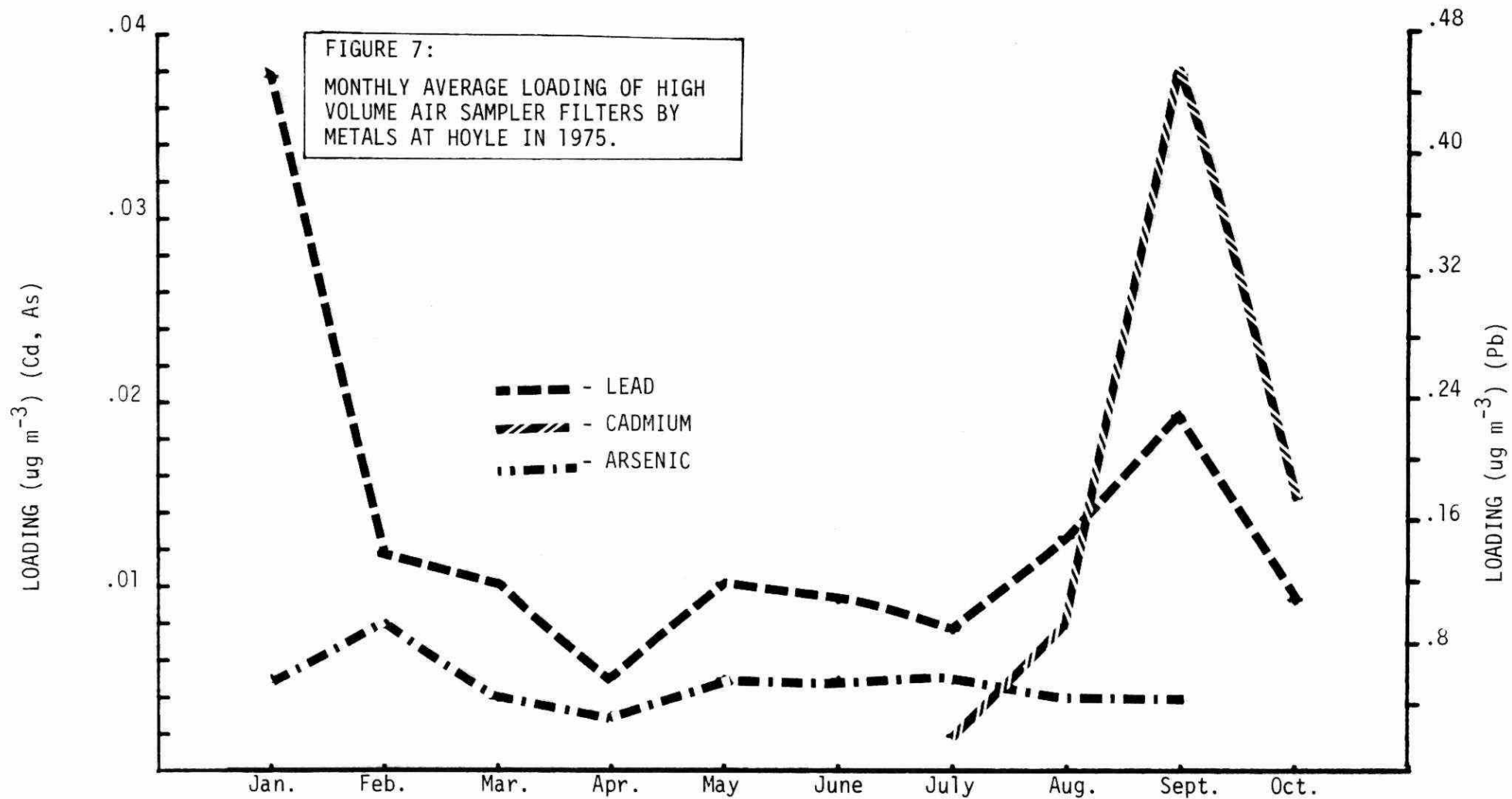


Table 1

SUMMARY OF CONDITION OF TAGGED TREMBLING ASPEN TREES IN
SURVEILLANCE PLOTS IN THE TIMMINS AREA - 1975

PARAMETER	<u>PLOT</u>												TOTAL OR MEAN
	1	2	3	4	5	6	7	8	8A	9	10	11	
YEAR ESTABLISHED	1975	1973	1970	1970	1970	1970	1970	1973	1975	1973	1970	1973	---
TOTAL DEAD	0	0	0	1	1	1	0	0	0	0	0	0	3
TOTAL DECLINED	--	0	1	2	2	4	1	0	--	1	1	0	12
DECLINED IN 1975	0	0	1	1	1	4	1	0	0	0	1	0	9
IMPROVED IN 1975	0	0	1	0	1	0	0	0	0	0	0	1	3
<u>FOMES</u> HEART ROT	0	0	0	1	0	0	0	0	0	2	0	0	3
<u>HYPOXYLON</u> CANKER	0	0	0	2	7	0	1	2	0	1	1	1	15
INSECT SEVERITY** - JUNE	--	1.0	1.0	1.0	2.4	1.0	1.0	3.3	--	1.0	1.0	1.0	1.4
INSECT SEVERITY - JULY	3.1	2.9	2.9	2.8	4.1	2.6	3.3	4.7	2.6	3.3	1.2	1.4	2.9
INSECT SEVERITY - AUG.	4.5	3.5	4.5	4.4	5.5	4.0	4.4	6.7	5.0	5.3	4.8	3.3	4.7
HEIGHT (M) 1975	11.5	14.0	17.2	14.8	11.9	19.7	12.5	14.6	9.1	15.3	10.8	23.5	14.6
DIAMETER (CM) 1975	11.37	11.42	15.41	13.75	14.53*	14.86	10.77	12.04	9.40	21.00	9.27	18.21	13.50
GROWTH RATE 1975 (CM/YR)***	---	.32	.35	.08	.09*	.05	.10	.16	--	.26	.14	.28	.18
AVERAGE GROWTH RATE (CM/YR)	---	.31	.26	.24	.36	.25	.20	.29	--	.47	.16	.38	.24

* FOR NON-CANKERED TREES ONLY

** SEVERITY RATING SYSTEM DESCRIBED IN TEXT

*** GROWTH RATE EQUALS INCREASE IN DBH PER YEAR

Table 2

CONCENTRATIONS OF ZINC (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

PLOT NO.	LOCATION*	YEAR					
		1970	1971	1972	1973	1974	1975
1	.8 km ENE	--	--	--	--	1950	1502
2	2.2 km ENE	--	--	--	--	515	493
3	3.2 km NE	300	507	--	614	820	425
4	8.0 km NE	270	186	253	147	186	377
5	16.1 km NE	265	240	262	279	385	397
6	8.0 km E	266	281	207	189	256	256
7	16.1 km E	152	132	155	109	222	185
8	.8 km SW	--	--	--	--	504	318
9	1.6 km SW	--	--	--	--	234	450
10	16.1 km SW	310	227	191	147	260	256
11	32.2 km WSW	--	--	--	--	230	453
OLD #1	1.6 km E	280	314	470	550	710	--

* Distance and Direction from Zinc Smelter

- 1975 values represent means of triplicate samples

Table 3

CONCENTRATIONS OF COPPER (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

<u>PLOT NO.</u>	<u>LOCATION*</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
1	.8 km ENE	—	—	—	61	87
2	2.2 km ENE	—	—	—	14	13
3	3.2 km NE	14	--	13	16	13
4	8.0 km NE	9	9	9	9	11
5	16.1 km NE	9	13	4	11	11
6	8.0 km E	8	8	4	8	10
7	16.1 km E	7	8	8	9	8
8	.8 km SW	--	--	--	16	12
9	1.6 km SW	--	--	--	7	10
10	16.1 km SW	8	10	8	9	10
11	32.2 km WSW	--	--	--	9	13
OLD #1	1.6 km E	13	15	13	10	--

* Distance and Direction from Zinc Smelter

- 1975 values represent means of triplicate samples

Table 4

CONCENTRATIONS OF LEAD (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

<u>PLOT NO.</u>	<u>LOCATION *</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>
1	.8 km ENE	--	--	--	29	37
2	2.2 km ENE	--	--	--	9	8
3	3.2 km NE	10	--	8	15	9
4	8.0 km NE	4	18	9	10	7
5	16.1 km NE	6	17	5	10	7
6	8.0 km E	8	14	6	12	10
7	16.1 km E	4	7	7	6	4
8	.8 km SW	--	--	--	13	8
9	1.6 km SW	--	--	--	7	7
10	16.1 km SW	5	11	15	10	10
11	32.2 km WSW	--	--	--	6	10
OLD # 1	1.6 km E	6	22	7	18	--

* Distance and Direction from Zinc Smelter

- 1975 values represent means of triplicate samples

Table 5

CONCENTRATIONS OF CADMIUM (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

<u>PLOT NO.</u>	<u>LOCATION*</u>	<u>YEAR</u>					
		1970	1971	1972	1973	1974	1975
1	.8 km ENE	--	--	--	--	7.5	7.5
2	2.2 km ENE	--	--	--	--	1.5	3.1
3	3.2 km NE	1.1	2.4	--	2.8	6.0	3.4
4	8.0 km NE	.3	.8	1.6	1.0	1.5	1.9
5	16.1 km NE	.6	1.2	1.2	.4	3.0	3.6
6	8.0 km E	.7	2.1	1.6	.8	2.0	2.3
7	16.1 km E	.1	.3	1.0	.5	1.0	1.0
8	.8 km SW	--	--	--	--	1.0	1.6
9	1.6 km SW	--	--	--	--	1.0	1.5
10	16.1 km SW	.7	.9	1.9	.7	1.0	1.3
11	32.2 km WSW	--	--	--	--	1.0	2.8
OLD #1	1.6 km E	.5	1.3	2.2	2.1	3.0	--

* Distance and Direction from Zinc Smelter

- 1975 values represent means of triplicate samples

Table 6

CONCENTRATIONS OF ARSENIC (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

PLOT NO.	LOCATION*	YEAR				
		1970	1971	1972	1973	1975
1	.8 km ENE	--	--	--	--	4.6
2	2.2 km ENE	--	--	--	--	.4
3	3.2 km NE	.5	.8	--	.3	.4
4	8.0 km NE	.7	.5	.8	.3	.3
5	16.1 km NE	.5	.6	.5	.3	.3
6	8.0 km E	.5	.9	.6	.5	.3
7	16.1 km E	.5	.8	.6	.2	.3
8	.8 km SW	--	--	--	--	.3
9	1.6 km SW	--	--	--	--	.5
10	16.1 km SW	.6	.9	.8	.4	.3
11	32.2 km WSW	--	--	--	--	.3
OLD #1	1.6 km E	.5	1.3	.8	.4	--

* Distance and Direction from Zinc Smelter

- 1975 values represent means for triplicate samples

Table 7

CONCENTRATIONS OF IRON (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

<u>PLOT NO.</u>	<u>LOCATION*</u>	<u>YEAR</u>				
		1970	1971	1972	1973	1974
1	.8 km ENE	--	--	--	--	385
2	2.2 km ENE	--	--	--	--	91
3	3.2 km NE	130	97	--	75	106
4	8.0 km NE	71	52	94	68	80
5	16.1 km NE	33	50	53	59	71
6	8.0 km E	46	69	51	57	82
7	16.1 km E	59	55	63	82	67
8	.8 km SW	--	--	--	--	102
9	1.6 km SW	--	--	--	--	55
10	16.1 km SW	38	60	69	80	20
11	32.2 km WSW	--	--	--	--	50
OLD # 1	1.6 km E	67	82	92	90	105

* Distance and Direction from Zinc Smelter

- No analysis for iron in 1975

Table 8

CONCENTRATIONS OF SULPHUR (%) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

PLOT NO.	LOCATION*	YEAR				
		1970	1971	1972	1973	1974
1	.8 km ENE	--	--	--	--	.33
2	2.2 km ENE	--	--	--	--	.33
3	3.2 km NE	.22	.23	.34	.19	.23
4	8.0 km NE	.22	.21	.26	.16	.19
5	16.1 km NE	.23	.29	.31	.25	.27
6	8.0 km E	.16	.20	.21	.17	.16
7	16.1 km E	.27	.21	.23	.20	.17
8	.8 km SW	--	--	--	--	.15
9	1.6 km SW	--	--	--	--	.17
10	16.1 km SW	.21	.26	.27	.20	.19
11	32.2 km WSW	--	--	--	--	.28
OLD #1	1.6 km E	.22	.23	.32	.26	.26

* Distance and Direction from Zinc Smelter

Table 9

CONCENTRATIONS OF SILVER (ppm) IN
TREMBLING ASPEN FOLIAGE COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

<u>PLOT NO.</u>	<u>LOCATION</u>	<u>YEAR</u>		
		1971	1972	1973
1	.8 km ENE	--	--	--
2	2.2 km ENE	--	--	--
3	3.2 km NE	.6	--	.5
4	8.0 km NE	.4	.3	.4
5	16.1 km NE	.6	.3	.5
6	8.0 km E	.4	.4	.5
7	16.1 km E	.3	.3	.2
8	.8 km SW	--	--	--
9	1.6 km SW	--	--	--
10	16.1 km SW	.4	.3	.4
11	32.2 km WSW	--	--	--
OLD #1	1.6 km E	.6	.9	.5

* Distance and Direction from Zinc Smelter

Table 10

CONCENTRATIONS OF ZINC (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

		(Year and Depth of Sample)											
Plot No.	Location*	1970	1971	1972	1973			1974			1975		
		0-10	0-10	0-10	0-5	5-10	10-15	0-5	5-10	10-15	0-5	5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	1513	177	35	1355	178	119
2	2.2 km ENE	-	-	-	-	-	-	58	30	22	110	34	21
3	3.2 km NE	51	775	1175	1250	869	938	264	108	50	188	74	69
4	8.0 km NE	42	81	34	67	39	38	38	58	40	44	39	38
5	16.1 km NE	100	234	147	168	103	100	175	125	122	187	140	93
6	8.0 km E	132	201	132	67	227	88	115	97	98	148	112	92
7	16.1 km E	39	61	25	57	53	187	32	33	30	43	22	31
8	.8 km SW	-	-	-	-	-	-	332	76	148	716	236	165
9	1.6 km SW	-	-	-	-	-	-	95	91	68	210	122	104
10	16.1 km SW	36	40	63	49	29	21	--	50	43	104	43	39
11	32.2 km	-	-	-	-	-	-	170	160	120	182	134	124
	(Old #1) 1.6 km E	280	238	327	681	124	74	1338	168	187			

*Distance and Direction from Zinc Plant

- 1975 Values Represent Means of Triplicate Samples.

Table 11

CONCENTRATIONS OF COPPER (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

		(Year and Depth of Sample)										
Plot No.	Location*	<u>1971</u>	<u>1972</u>	<u>1973</u>			<u>1974</u>			<u>1975</u>		
		0-10	0-10	0-5	5-10	10-15	0-5	5-10	10-15	0-5	5-10	10-15
1	.8 km ENE	-	-	-	-	-	345	40	26	334	51	37
2	2.2 km ENE	-	-	-	-	-	22	19	13	26	16	12
3	3.2 km NE	289	-	346	226	226	108	43	34	55	22	24
4	8.0 km NE	17	15	23	12	10	23	22	18	25	22	19
5	16.1 km NE	27	19	25	16	18	42	35	28	39	27	24
6	8.0 km E	31	20	13	13	18	38	32	35	33	28	30
7	16.1 km E	4	6	7	7	4	12	13	12	17	11	12
8	.8 km SW	-	-	-	-	-	112	42	52	145	78	56
9	1.6 km SW	-	-	-	-	-	33	33	32	55	42	41
10	16.1 km SW	9	14	18	11	8	-	15	10	32	20	16
11	32.2 km WSW	-	-	-	-	-	48	40	33	61	49	48
(Old #1) 1.6 km E		56	88	182	21	20	469	42	31			

*Distance and Direction from Zinc Plant

- 1975 Values Represents Means of Triplicate Samples.

Table 12

CONCENTRATIONS OF LEAD (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	1971 0-10	1972 0-10	0-5	1973 5-10	10-15	0-5	1974 5-10	10-15	0-5	1975 5-10	10-15
1	.8 km ENE	-	-	-	-	-	63	14	15	82	29	25
2	2.2 km ENE	-	-	-	-	-	17	14	11	13	8	7
3	3.2 km NE	49	52	32	37	41	20	13	15	30	18	18
4	8.0 km NE	17	23	24	14	12	25	24	19	18	14	12
5	16.1 km NE	31	35	28	22	23	40	36	32	29	19	21
6	8.0 km E	37	27	12	24	22	43	38	39	35	23	27
7	16.1 km E	8	23	15	5	8	18	12	12	22	10	10
8	.8 km SW	-	-	-	-	-	55	32	42	58	39	39
9	1.6 km SW	-	-	-	-	-	38	37	29	57	37	33
10	16.1 km SW	14	34	42	14	11	-	23	13	61	20	19
11	32.2 km WSW	-	-	-	-	-	35	35	28	31	29	31
(Old #1)	1.6 km E	37	38	50	22	20	89	33	32			

*Distance and Direction from Zinc Plant

-1975 Values Represent Means of Triplicate Samples.

Table 13

CONCENTRATIONS OF CADMIUM (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	1970 0-10	1971 0-10	1972 0-10	0-5	1973 5-10	10-15	0-5	1974 5-10	10-15	0-5	1975 5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	12.0	3.0	3.0	9.5	1.7	1.3
2	2.2 km ENE	-	-	-	-	-	-	ND	ND	ND	1.2	.8	.8
3	3.2 km NE	.1	.3	.7	9.7	5.9	2.8	4.0	ND	ND	2.2	1.3	1.2
4	8.0 km NE	.2	.3	.5	1.9	.9	.7	3.0	4.0	4.0	1.6	1.2	1.2
5	16.1 km NE	.1	.6	1.0	2.4	.9	1.1	4.0	4.0	4.0	1.6	1.5	1.5
6	8.0 km E	.2	.3	.7	2.0	.7	.7	4.0	4.0	4.0	1.9	1.4	1.4
7	16.1 km E	.2	.3	.6	1.8	.6	.7	ND	5.0	5.0	1.1	1.0	.9
8	.8 km SW	-	-	-	-	-	-	6.0	4.0	4.0	5.5	2.6	1.9
9	1.6 km SW	-	-	-	-	-	-	4.0	4.0	3.0	2.5	1.9	1.8
10	16.1 km SW	.2	.4	.5	3.0	.9	.7	-	3.0	ND	1.5	1.0	1.0
11	32.2 km WSW	-	-	-	-	-	-	3.0	3.0	3.0	1.7	1.5	1.6
	(Old #1) 1.6 km E	.2	.3	.9	4.7	1.1	2.1	9.0	4.0	4.0	-	-	-

*Distance and Direction from Zinc Plant

- 1975 Values Represent Means of Triplicate Samples.

Table 14

CONCENTRATIONS OF CADMIUM (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	1970 0-10	1971 0-10	1972 0-10	0-5	1973 5-10	10-15	0-5	1974 5-10	10-15	0-5	1975 5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	12.0	3.0	3.0	9.5	1.7	1.3
2	2.2 km ENE	-	-	-	-	-	-	ND	ND	ND	1.2	.8	.8
3	3.2 km NE	4	6.0	6.4	9.7	5.9	2.8	4.0	ND	ND	2.2	1.3	1.2
4	8.0 km NE	< 3	1.9	2.7	1.9	.9	.7	3.0	4.0	4.0	1.6	1.2	1.2
5	16.1 km NE	< 3	2.3	1.9	2.4	.9	1.1	4.0	4.0	4.0	1.6	1.5	1.5
6	8.0 km E	< 3	2.2	2.0	2.0	.7	.7	4.0	4.0	4.0	1.9	1.4	1.4
7	16.1 km E	< 3	.7	1.5	1.8	.6	.7	ND	5.0	5.0	1.1	1.0	.9
8	.8 km SW	-	-	-	-	-	-	6.0	4.0	4.0	5.5	2.6	1.9
9	1.6 km SW	-	-	-	-	-	-	4.0	4.0	3.0	2.5	1.9	1.8
10	16.1 km SW	< 3	.5	1.9	3.0	.9	.7	-	3.0	ND	1.5	1.0	1.0
11	32.2 km WSW	-	-	-	-	-	-	3.0	3.0	3.0	1.7	1.5	1.6
	(Old #1) 1.6 km E	< 3	2.2	2.8	4.7	1.1	2.1	9.0	4.0	4.0	-	-	-

*Distance and Direction from Zinc Plant

- 1975 Values Represent Means of Triplicate Samples.

Table 15

CONCENTRATIONS OF ARSENIC (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	1970	1971	1972	1973			1975		
		0-10	0-10	0-10	0-5	5-10	10-15	0-5	5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	6.1	2.6	2.3
2	2.2 km ENE	-	-	-	-	-	-	1.7	1.6	1.2
3	3.2 km NE	1.9	1.0	1.3	4.8	4.0	3.5	3.1	2.9	1.8
4	8.0 km NE	.5	1.8	.9	2.6	1.6	1.3	1.4	1.4	1.4
5	16.1 km NE	.5	.8	.8	2.6	2.3	.3	2.9	2.7	2.9
6	8.0 km E	.5	.8	.7	2.6	3.0	3.4	3.7	3.4	3.6
7	16.1 km E	.5	.8	.9	.6	.6	.6	2.1	1.1	1.0
8	.8 km SW	-	-	-	-	-	-	6.8	4.2	4.3
9	1.6 km SW	-	-	-	-	-	-	6.9	5.4	4.1
10	16.1 km SW	.9	1.3	.6	3.0	1.7	1.4	9.1	1.5	.5
11	32.2 km WSW	-	-	-	-	-	-	2.9	3.0	2.5
	(Old #1) 1.6 km E	.5	1.5	.7	4.2	4.0	3.8			

*Distance and Direction from Zinc Plant

Table 16

CONCENTRATIONS OF IRON (%) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	<u>1970</u> 0-10	<u>1971</u> 0-10	<u>1972</u> 0-10	0-5	<u>1973</u> 5-10	10-15	0-5	<u>1974</u> 5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	.40	.83	1.38
2	2.2 km ENE	-	-	-	-	-	-	.43	.47	.51
3	3.2 km NE	.72	2.16	1.15	.91	1.03	1.19	1.08	.44	.44
4	8.0 km NE	1.65	1.15	1.30	1.19	.81	.78	.99	1.27	1.53
5	16.1 km NE	2.37	3.25	2.65	1.94	2.31	2.04	2.52	2.88	2.98
6	8.0 km E	4.15	4.23	3.00	1.18	1.07	1.32	2.41	2.57	2.45
7	16.1 km E	.72	.48	.65	.17	.56	.60	.54	.91	1.00
8	.8 km SW	-	-	-	-	-	-	1.67	2.60	2.44
9	1.6 km SW	-	-	-	-	-	-	1.76	1.84	2.37
10	16.1 km SW	.78	.92	1.01	.21	1.23	1.09	-	1.53	1.53
11	32.2 km WSW	-	-	-	-	-	-	4.25	3.75	4.00
	(Old #1) 1.6 km E	2.32	3.53	3.35	1.16	1.69	2.07	3.34	4.40	4.05

*Distance and Direction from Zinc Plant

Table 17

CONCENTRATIONS OF SULPHUR (%) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS
(Year and Depth of Sample)

Plot No.	Location*	1970	1971	1972	1973			1974		
		0-10	0-10	0-10	0-5	5-10	10-15	0-5	5-10	10-15
1	.8 km ENE	-	-	-	-	-	-	.33	.04	.02
2	2.2 km ENE	-	-	-	-	-	-	.28	.02	.02
3	3.2 km NE	.20	.18	.17	.21	.15	.16	.03	.02	.02
4	8.0 km NE	.05	.04	.06	.07	.04	.04	.06	.06	.03
5	16.1 km NE	.01	.11	.03	.05	.03	.03	.05	.03	.02
6	8.0 km E	.03	.05	.02	.04	.02	.02	.04	.02	.02
7	16.1 km E	.02	.04	.02	.01	.03	.02	.04	.02	.01
8	.8 km SW	-	-	-	-	-	-	.10	.06	.10
9	1.6 km SW	-	-	-	-	-	-	.14	.12	.03
10	16.1 km SW	.04	.03	.05	.12	.06	.03	.04	.02	.02
11	32.2 km WSW	-	-	-	-	-	-	.05	.03	.01
	(01d #1) 1.6 km E	.10	.04	.03	.14	.02	.03	.21	.05	.02

*Distance and Direction from Zinc Plant

Table 18

CONCENTRATIONS OF SILVER (ppm) IN SOIL
COLLECTED AT THE TIMMINS SURVEILLANCE PLOTS

(Year and Depth of Sample)

Plot No.	Location*	<u>1971</u> 0-10	<u>1972</u> 0-10	0-5	<u>1973</u> 5-10	10-15
1	.8 km ENE	-	-	-	-	-
2	2.2 km ENE	-	-	-	-	-
3	3.2 km NE	.3	.3	.5	.7	.7
4	8.0 km NE	.3	.3	.6	.3	.3
5	16.1 km NE	.3	.3	.5	.7	.6
6	8.0 km E	.2	.2	.9	.3	.9
7	16.1 km E	.3	.4	.7	.7	ND
8	.8 km SW	-	-	-	-	-
9	1.6 km SW	-	-	0	-	-
10	16.1 km SW	.3	.4	.7	.7	.7
11	32.2 km WSW	-	-	-	-	-
	(Old #1) 1.6 km E	.3	.3	.7	.4	.7

*Distance and Direction from Zinc Plant

Table 19

PARTICULATE LOADING ON THE HIGH VOLUME
FILTERS FOR 1975 IN THE TIMMINS AREA*

Date	Particulate Loading (ug/m ³)	Date	Particulate Loading (ug/m ³)
January 24	24	July 2	90
January 30	35	July 15	99
February 5	24	July 18	112
February 11	14	July 25	48
February 17	13	July 30	53
February 23	13	August 5	59
March 7	40	August 20	64
April 12	8	August 25	105
April 18	30	August 29	40
April 24	17	September 5	103
April 30	30	September 23	127
May 7	35	September 29	184
May 13	115	October 6	26
May 20	35	October 10	18
May 26	31	October 16	72
June 2	22		
June 6	42		
June 12	32		
June 18	135		
June 24	43		

* Ontario Criteria for Suspended Particulate Matter:

- 24 Hours: 120 ug/m³
- 1 year: 60 ug/m³ (geometric mean)

Table 20

TRACE ELEMENTS IN THE HIGH VOLUME FILTERS FOR 1975
IN THE TIMMINS AREA

(All values in micrograms/cubic metre)

Date	As	Cd	Cu	Fe	Pb	Ni	Zn
January 24					0.34		
January 30	0.005				0.57		3.97
February 5	0.010	0.014			0.06		0.16
February 11	0.004				0.21		0.38
February 17	0.006	0.003			0.23		ND
February 23	0.004	0.005			0.06		0.16
March 7	0.004				0.12		
April 12	0.001				ND		
April 18	0.007				0.12		0.16
April 24	0.002				ND		0.46
April 30	0.002				0.12		0.29
May 7	0.002				0.12		1.21
May 13	0.005				0.25		2.94
May 20	0.009				ND		0.21
May 26	0.005				0.12		0.20
June 2	0.002				ND		0.20
June 6	0.003				0.13		0.82
June 12	0.002				0.12		0.24
June 18	0.015				0.23		3.51
June 24	0.003				0.09		0.24
July 2	0.003				0.13		0.85
July 15	0.008				0.09		0.71
July 18	0.003				ND		0.53
July 25	0.006	0.003	0.13	1.53	0.15	ND	0.38
July 30	0.006	0.001	0.18	2.17	0.10	ND	0.50
August 5	0.005	ND	0.20	0.93	0.05	ND	0.45
August 20	0.002	0.006	0.26	1.79	0.21	ND	0.12
August 25	0.005	0.004	0.36	3.79	0.14	0.01	0.88
August 29	0.005	0.021	0.43	1.92	0.19	ND	3.36
September 5	0.002	0.095	0.31	3.26	0.22	ND	0.50
September 23	0.006	0.011	0.71	3.78	0.33	0.04	0.26
September 29		0.006	0.21	3.55	0.13	0.03	1.01
October 6		0.002	0.35	0.60	0.09	ND	0.10
October 10		0.013	0.19	0.31	0.09	ND	1.00
October 16		0.030	0.38	2.68	0.25	0.03	1.50

Table 21 SULPHATION RATES RECORDED FOR 1975 ON THE LEAD
PEROXIDE CANDLES AND PLATES EXPOSED IN THE TIMMINS
AREA EXPRESSED AS $\text{mg SO}_3/100 \text{ cm}^2/\text{DAY}$

Distance and Direction From Hoyle	May	June	July	August	September	Mean
.8 km ENE	-	-	-	.36	.25	.30
* 1.6 km ENE	.05	.05	.12	-	-	.07
2.2 km ENE	.05	.03	.09	.05	.03	.05
3.2 km NE	.05	.05	.07	.05	.03	.05
8.0 km NE	.04	.03	.05	.04	.03	.04
16.0 km NE	.07	.04	.11	.05	.04	.06
8.0 km E	.05	.03	.03	.04	.03	.04
16.0 km E	.05	.03	.06	.04	.03	.04
.8 km SW	.08	.06	.05	.04	.06	.06
1.6 km SW	.03	.02	.06	.03	.03	.03
16.0 km SW	.04	.03	.04	.04	.03	.04
32.0 km WSW	.04	.06	.03	.04	.03	.04

* - Sulphation Plate

Ontario Criterion - $0.7 \text{ mg SO}_3/100 \text{ cm}^2/30 \text{ days}$.

Table 22

CONCENTRATIONS OF CHEMICAL ELEMENTS IN VEGETATION
COLLECTED AT RAILROAD STUDY SITE #1-TIMMINS*

Species	Date	Element (ppm)			
		Zn	Cu	Pb	Cd
Raspberry	June 26/75	966	66	24	4.1
	July 23/75	1390	105	38	9.8
Raspberry	Control	125	6	21	1
Trembling Aspen	July 23/75	1430	37.3	18	9.8
Trembling Aspen	Control	200	9	9	1

* Values Represent Means of Triplicate Samples

Table 23

CONCENTRATIONS OF CHEMICAL ELEMENTS IN RASPBERRY FOLIAGE
COLLECTED AT TIMMINS RAILROAD STUDY SITES - JUNE,*
1975

Site	Distance** (m)	Element (ppm)					
		Zn	Cu	Pb	Cd	Fe	As
1	0	966	67	24	4.1	385	1.3
	50	717	54	24	2.7	268	1.8
	100	617	56	29	3.0	285	1.6
2	0	38	64	21	2.2	340	1.4
	50	255	39	25	1.3	267	.8
	100	350	60	29	2.2	348	1.1
3	0	(140)	(21)	(12)	(2.5)	(440)	(.7)
	50	262	297	16	1.4	71	.5
	100	223	25	16	1.5	390	.7
4	0	313	30	12	1.5	303	.4
	50	187	18	12	1.0	178	.5
	100	90	24	8	.7	127	.3
5	0	68	14	9	.7	153	.3
	50	190	47	10	1.1	213	.4
	100	64	12	9	.8	183	ND
6	0	250	26	16	1.0	233	.3
	50	138	16	23	1.0	563	ND
	100	(150)	(19)	(18)	(1.2)	(127)	(ND)
Control		125	6	21	1	200	--

* - Values represent means of triplicate samples except values in brackets where there was sufficient plant material for a single sample only.

** - Distance from Railroad property line.

Table 24

STATISTICAL SUMMARY OF SIGNIFICANT DIFFERENCES OF METAL
CONCENTRATIONS IN RASPBERRY FOLIAGE - TIMMINS RAILROAD STUDY-1975

Site Number	Zn	Cu	Element	Cd	Fe
			Pb		
1	a ¹	b	a	a	ab
2	b	b	b	b	a
3	b	a	d	b	bc
4	b	b	e	c	c
5	b	b	e	c	c
6	b	b	c	c	a

¹ Sites indicated by the same letter within columns are not significantly different from each other (P = .01).

Table 25

TIMMINS RAILROAD STUDY
CONCENTRATION OF ZINC (ppm) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	4377	795	213
	50	970	94	163
	100	1337	234	117
2	0	442	114	72
	50	369	177	62
	100	271	104	67
3	0	309	29	20
	50	234	36	39
	100	132	61	27
4	0	5710	746	417
	50	254	75	131
	100	148	60	23
5	0	492	158	65
	50	141	75	56
	100	102	65	59
6	0	530	183	64
	50	463	141	122
	100	234	123	116
Control		182	134	124

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 26

TIMMINS RAILROAD STUDY
CONCENTRATION OF COPPER (ppm) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	1033	180	104
	50	166	24	33
	100	229	46	36
2	0	157	46	35
	50	153	56	28
	100	72	19	13
3	0	111	6	5
	50	50	14	13
	100	25	10	13
4	0	1433	138	78
	50	55	18	27
	100	23	10	5
5	0	102	23	14
	50	28	14	13
	100	17	10	10
6	0	273	80	31
	50	122	27	22
	100	70	31	29
Control		61	49	48

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 27

TIMMINS RAILROAD STUDY
CONCENTRATION OF LEAD (ppm) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	145	45	29
	50	45	23	27
	100	71	33	29
2	0	51	30	23
	50	102	57	49
	100	49	32	21
3	0	13	10	8
	50	18	10	10
	100	13	10	11
4	0	165	37	23
	50	16	8	9
	100	8	5	ND
5	0	20	15	12
	50	20	16	21
	100	14	13	13
6	0	48	28	27
	50	50	44	29
	100	44	36	30
Control		31	29	31

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 28

TIMMINS RAILROAD STUDY
CONCENTRATION OF CADMIUM (ppm) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	29.6	5.3	2.6
	50	6.0	1.4	1.6
	100	7.7	2.1	1.6
2	0	5.2	2.4	1.3
	50	4.1	3.9	3.8
	100	2.1	1.0	.7
3	0	2.0	.5	.5
	50	1.4	.6	.8
	100	.8	.8	1.0
4	0	30.4	4.5	3.7
	50	2.2	1.3	1.3
	100	1.0	.8	.5
5	0	2.7	1.3	.9
	50	1.4	1.4	1.4
	100	1.3	1.0	.9
6	0	3.8	1.8	1.8
	50	3.0	1.5	1.5
	100	2.4	1.5	1.5
Control		1.7	1.5	1.6

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 29

TIMMINS RAILROAD STUDY
CONCENTRATION OF IRON (%) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	1.90	1.53	1.27
	50	1.60	2.23	2.25
	100	2.71	3.13	3.21
2	0	1.47	2.13	2.54
	50	1.79	1.42	1.07
	100	1.58	1.47	1.37
3	0	.29	.17	.31
	50	.99	.94	.86
	100	.66	.79	.88
4	0	4.38	5.58	4.11
	50	.59	1.48	.72
	100	.94	.80	.54
5	0	.84	.86	.79
	50	1.05	1.00	.94
	100	1.12	1.13	1.07
6	0	1.10	.95	.29
	50	2.58	3.00	3.17
	100	2.21	2.92	3.38
Control		2.90	3.00	2.50

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 30

TIMMINS RAILROAD STUDY
CONCENTRATION OF ARSENIC (ppm) IN SOIL*- JUNE 1975

Site	Distance** (m)	Soil Depth (cm)		
		0-5	5-10	10-15
1	0	9.1	2.9	2.1
	50	3.5	2.3	2.4
	100	5.1	3.3	2.9
2	0	6.0	7.7	5.9
	50	78.1	30.5	7.7
	100	2.8	2.1	1.7
3	0	1.1	.4	.5
	50	1.6	1.3	1.1
	100	1.4	.9	1.0
4	0	11.1	12.6	8.2
	50	3.2	8.1	4.1
	100	4.2	3.4	1.9
5	0	1.6	1.1	.9
	50	1.3	1.2	1.1
	100	1.3	1.0	.9
6	0	3.1	1.6	.5
	50	3.7	3.5	3.3
	100	3.4	3.7	3.8
Control		2.9	3.0	2.5

* -Values represent means of triplicate samples

** -Distance from Railroad property line

Table 31

STATISTICAL SUMMARY OF SIGNIFICANT DIFFERENCES OF METAL
CONCENTRATIONS IN SOIL - TIMMINI RAILROAD STUDY - 1975

Source of Variations	Element				
	Zn	Cu	Pb	Cd	Fe
<u>Site Number</u>					
1	a ¹	a	a	a	a
2	b	b	a	b	a
3	b	b	c	b	b
4	a	a	ab	a	a
5	b	b	bc	b	b
6	b	b	a	b	a
<u>Distance</u>					
0 m	a	a	a	a	a
50 m	b	b	ab	b	a
100 m	b	b	b	b	a
<u>Depth</u>					
0-5 cm	a	a	a	a	a
5-10 cm	b	b	b	b	a
10-15 cm	b	b	b	b	a

¹ Sites, distances or depths indicated by the same letter within columns are not significantly different from each other (P = .01).

CONCENTRATION OF CHEMICAL ELEMENTS IN TREMBLING ASPEN AND SOIL
COLLECTED 100 m S OF ZINC REFINERY - TIMMINS -
1975

<u>Trembling Aspen:</u>	<u>Zn</u>	<u>Cu</u>	<u>Pb</u>	<u>Cd</u>
100 m S of zinc refinery-June	1873	98	427	25.0
100 m S of zinc refinery-July	1470	54	22	6.3
Control Site-32 km WSW-June	387	10	8	1.3
Control Site-32 km WSW-July	453	13	10	2.8

Soil:

100 m S of zinc refinery-July

0-5 cm	1400	118	56	5.6
5-10 cm	213	38	34	1.6
10-15 cm	131	45	34	1.3

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